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TRICHINOSIS - INCIDENCE AND TREATMENT
OF MEAT FOR SAFETY

Paul J. Brandly

Trichinosis has hung as the "sword of Damocles" over the American pork industry since Zenker discovered in 1859 that trichinous pork could cause severe and fatal disease in man. In Europe, with the tight government control and regimentation, it has been possible to protect the public from the disease by careful microscopic examination of each swine and carnivore carcass slaughtered for food. There, pork does not carry the stigma of potential danger. In the United States, the freedom of slaughter, without inspection, by any swine owner prevents consideration of trichinoscopic examination as a means of control.

A review of the life cycle of Trichinella spiralis and a brief history of the disease may be of value to those non-parasitologically trained. The life cycle is unique in that its entire span occurs in one host. Ingested larvae are freed from their muscle capsule by the digestive process. The larvae mature, mate and, within three days, the female embeds herself deeply within the mucosa of the small intestine and begins to give birth to 1,000 to 1,500 living larvae that she will normally produce. The larvae penetrate the mucosa, gain access to the blood and many find their way to striated skeletal muscle. Those larvae which enter these muscle fibers, encyst and develop into a tight coil in a protective capsule where they remain for many years ready to infect any mammal which eats the muscle.

Dr. Brandly, Chief Staff Officer, Biological Sciences, Meat Inspection Division, Agricultural Research Service, United States Department of Agriculture. Paper presented at the 16th Annual American Meat Institute Foundation Research Conference, February 25-26, 1964, Chicago, Illinois.

The disease caused by T. spiralis occurs during the time the larvae are being produced and encysted in the muscle tissue. In many light infections, the host is never aware of the condition. Trichinosis can be produced only by the ingestion of trichina-infected muscle which contains appreciable numbers of viable trichinae. When recovery from the clinical stage is completed no further symptoms appear, however, once the infection is established, evidence of that infection will persist until the muscle tissue is destroyed.

The original recognition of the parasite was by James Paget, a first-year medical student at St. Bartholomew's Hospital in London, in 1835. He studied the parasite in human muscle under a microscope, and described the minute, coiled, encysted, round worms.

Leidy, in Philadelphia, in 1846 saw the larvae in pork muscle and recognized the morphologic similarity of the encysted trichina in man and swine.

During the period between Paget's findings and Zenker's discovery of the transmissibility of trichinosis from lower animals to man, many other workers reported the presence of trichina larvae in man and animals. Herbst, in 1851, demonstrated the transmission of the infection from animal to animal.

In 1859, the brilliant clinician, pathologist, and epidemiologist, F. A. Zenker, studied a case diagnosed as typhoid fever in a 20-year-old servant girl in Dresden, Germany. The clinical course of her illness was not characteristic of typhoid. Her muscles became extremely sensitive and she complained continuously of muscular pain. Zenker recorded his careful clinical observations of all the now generally recognized symptoms of trichinosis.

The patient died on the 33rd day and pathologic examination of the skeletal muscle failed to reveal the degeneration of the skeletal muscle characteristic of typhoid fever. However, Zenker did find innumerable, minute nematodes, many of which were encysted in the skeletal muscle with an extremely severe myositis with massive eosinophil infiltration. He also found larva-filled female nematodes in the mucosa of the small intestine. Zenker correctly postulated that the larvae penetrated the mucosa, entered the lymphatics, and thus the blood stream, and were distributed throughout the body.

With the perception, thoroughness, imagination, and perseverance with which few are endowed, Zenker carefully studied the environment, the activities, habits, and food consumption of the patient prior to her illness. He found that she had eaten generously of fresh, raw pork from a pig slaughtered in the household four days prior to the onset of her symptoms. Microscopic examination of remaining meat from that pig revealed numerous nematodes of the same size, type and character as those found in the muscles of the deceased.

Sir William Osler, in 1899, recognized Zenker's findings as being, without doubt, the foremost helminthological contribution of the nineteenth century.

Zenker turned his material over to Virchow, the father of modern pathology and to Leuckart, the most eminent parasitologist of his time. By 1863 (a hundred and one years ago), Virchow and Leuckart had fully developed the epidemiology, pathology, and control measures for this nematode. In the same year, Virchow traveled the length and breadth of Germany insisting upon the necessity for microscopic examination of each hog slaughtered for food, to detect infected and to eliminate trichinous carcasses from the human diet and prevent reinfection of swine. Virchow's microscopic control measures were necessitated by the raw-pork consumption habits of Germans and Middle Europeans, generally.

The success of the control of trichinosis in man by the microscopic examination of pork is dependent upon the inspection of each hog slaughtered. In the regimented society which Virchow knew and with which he was concerned, microscopic examination of each swine and carnivorous game carcass was possible and, therefore, microscopic examination was eminently successful. Following Virchow's recommendations there were trichinosis outbreaks in man in which microscopically examined swine were purported to have caused the disease. It is generally accepted, however, that these outbreaks resulted from swine slaughtered under clandestine circumstances and not subjected to microscopic examination.

More than 60 years have passed since there has been an outbreak of trichinosis in man in Germany traceable to inspected pork and there is no thought of risk when the German consumer eats raw pork. This assurance of safety allows pork, in any form, to be in the top bracket of consumer desirability in Germany.

The Scandinavian countries, employing these same techniques, have, for all practical purposes, eliminated trichina infections from their butcher hogs to the extent that only breeder swine are subjected to microscopic examination. A like circumstance exists in Mexico, where only breeder hogs are microscopically examined for trichinae, and pork has no stigma there. In countries such as France, where the culinary practices have traditionally provided for the thorough cooking of pork, trichinosis has never been a problem.

The following experiences emphasize the dangers inherent in a trichinosis control program based upon microscopic inspection of only a part of the pork supply.

During World War II, the German soldiers occupying France, and the German prisoners of war in the U.S.A., suffered appreciably from trichinosis because of their unquestioning confidence in the safety of raw pork.

During the period 1879-1891, American pork was denied entrance to Austria, France, Germany, Italy, Norway, Portugal and other European countries because of the presence of trichina in it. In 1890 and 1891, Congress passed laws which provided for the microscopic examination of pork intended for export and, the U.S.D.A. established trichinoscopic inspection of pork intended for export. American pork was once again accepted in the European markets in 1891. During the next 15 years, 578,533,079 pounds of American pork which had been microscopically examined were accepted in European markets. Germany, the largest importer of American pork, continued to examine American pork and occasionally found a lightly infected animal.

In order to understand the situation, it should be pointed out that many of the infected hogs (now more than 60%) have less than one trichina per gram of diaphragm muscle. In examining less than a gram of tissue, it is obvious that light infections will often be missed. The same circumstances occurred in Germany and it must be concluded that light infections are not a significant public health problem in view of the success of the German trichina control.

With the passage of the Federal Meat Inspection law in 1906, it was obvious to Federal authorities that microscopic examination of pork to control trichinosis in man, could be successful only if every individual swine carcass was microscopically examined. As only a part of the pork supply was federally inspected, this practice would give a false sense of security to the consumer as to the safety of all pork. Such assurance would promote the consumption of uncertified pork in the raw state with an increase of trichinosis in man.

The alternative control of trichinosis in man would be to destroy all trichina in products containing pork that are customarily eaten without further cooking, and to educate the consumer to thoroughly cook other pork products.

The Meat Inspection Division veterinarians, the home economists, and the Extension Service personnel, with the aid of school teachers, editors of cookbooks, newspapers, and magazines, inaugurated an extensive campaign designed to assure the thorough cooking of fresh pork.

The Meat Inspection Division, in cooperation with other agencies of the Department, developed thermal death times, freezing viability standards, and salt-concentration-time temperature data covering the destruction of trichina in meat. The results of these studies were incorporated in the Meat Inspection Division regulations and have proved to be adequate to protect the public from trichinosis that might otherwise have been acquired through processed pork products.

The educational campaign, with its continued reiteration of the danger of eating improperly prepared pork, placed a stigma on pork. For example, it has been reported that with the publication of an article on trichinosis in the Chicago newspapers, pork consumption in the Chicago area dropped 15% for the next six months.

The concern about trichinosis in man has resulted in many surveys of the prevalence of infection in man based on examination of muscles of human beings. In evaluating the significance of the findings, one must keep in mind that the majority of the specimens were from elderly people and, as the evidence of trichina infection acquired during 50 or more years would be present at the time of death, the objective evaluation of the current status of trichinosis would be impossible. This situation resulted in an average trichina infection rate of about 17% for all of these studies and it has been, and still is, widely quoted and generally accepted that one person in six in the United States has trichinosis.

In November 1963, I visited Dr. Kenneth MacDonald, Professor of Public Health, School of Medicine, Iowa University, where we discussed the significance of the results of studies of some 570 human samples collected at Iowa City. Dr. MacDonald, who is making a very significant contribution to the understanding of trichinosis in man, not only recorded the age of each individual but the number of trichina per gram of tissue. This allowed him to conclude that although 17.5% of his samples were positive, a very low percentage had enough trichina to ever have experienced any kind of symptom. In other words, the infection was so low that most individuals would never have known that they were infected.

Further evaluation of MacDonald's study showed that the rate of human infection per year of life prior to and after 1910 could be determined. Based upon the supposition that the eating habits at any one time were the same for all age groups, MacDonald's data indicated that for each 126 years of life prior to 1910 there was one positive human trichina case, while 967 years were required for the occurrence per positive case after 1910.

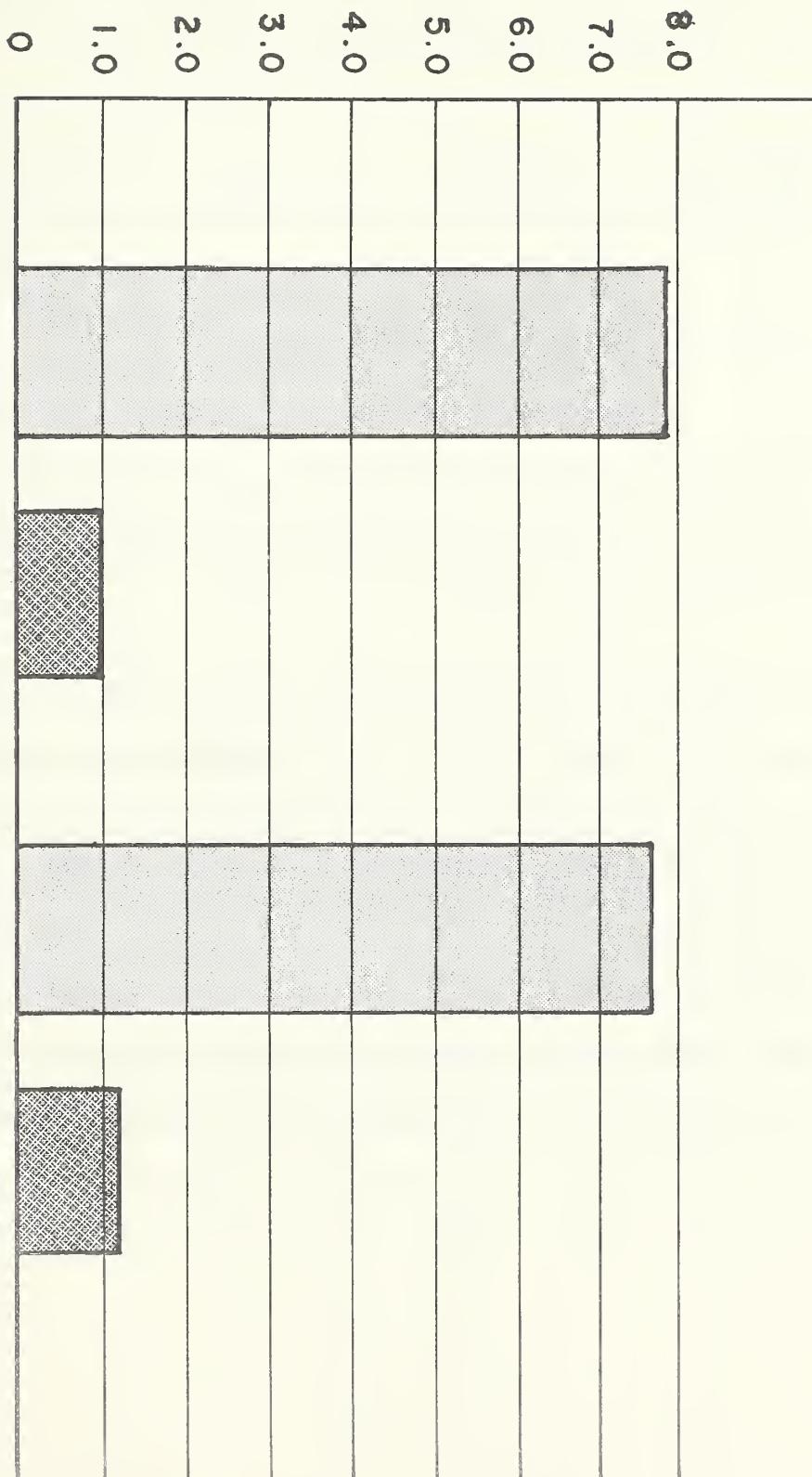
Table I shows the rate of decline of human infection before and after 1910. Applying this same method to the 1,229 cases collected by Gould in Detroit about 1940, it was found that the ratio was one positive case to each 130 life years before 1910 and one per 800 life years after 1910. Gould's figures involve 72,000+ life years of people born before 1910 and only 800 after 1910. No conclusions could be drawn from Gould's data until MacDonald's data, accumulated 20 years later pointed the way.

Recent reports from individual workers throughout the country report that less than 4% human muscle samples now contain trichina. One cannot help but admire the effectiveness of the trichina control program devised and launched by the Department of Agriculture in 1906. During the past 10 years, the average number of clinical cases reported to the U. S. Public Health Service has been 244 and the deaths from trichinosis have been reported at 4.8 per annum. The few human cases of trichinosis in the United States principally occurred in middle European ethnic groups who continued to occasionally eat raw pork.

This evidence of the significantly effective control of trichinosis in man, without widespread government controls, is reassuring and commendable and attests to the soundness of the program. So much for trichinosis in man.

HUMAN INCIDENCE PER
1,000 YEARS OF LIFE

Table I



MACDONALD

GOULD

Concerning the incidence of trichinosis in swine, it was found that during the microscopic examination for the European export of pork (1891-1906) covering 8,000,000 swine, approximately 3% of the carcasses examined contained trichina or trichina-like bodies. During the same time, it was learned that 12 to 20% of the garbage-fed swine were trichinous. By digestion techniques, Schwartz et al., in the 1930's found 0.95% of the farm raised hogs, and 5.81% of the garbage-fed hogs examined, to be positive for trichina.

The number of trichinae in 19 of 20 farm-raised hogs, both breeders and butchers, was less than one per gram and, it is generally believed that less than one trichina per gram of pork is unlikely to cause clinical trichinosis in man.

The Meat Inspection Division on March 29, 1961, in cooperation with the Iowa State Veterinary Research Institute, initiated a survey of porcine trichinosis in the U.S., and the figures cited cover samples examined through December 17, 1963. The samples consisted of 1.6 ounces of diaphragm muscle collected by meat inspectors and forwarded to Dr. William Zimmerman, Iowa State Veterinary Research Institute, Ames, Iowa, where they were studied by the artificial digestion Baermann's technique by Dr. Zimmerman. (See Table II)

Table II

RESULTS OF NATIONAL TRICHINA SURVEY OF 15,763 SWINE

March 29, 1961 through December 17, 1963

Type of Swine	Number Examined	Number Positive	Number with more than 1 Trichina per gram
Farm-Raised Butcher Hogs	6,265	8	0
Farm-Raised Breeder Hogs	6,036	12	1
Garbage-Fed Hogs	3,462	122	48

In the U. S. the primary danger to man from trichinous pork is from garbage-fed hogs. Among the former only one animal in more than 12,000 farm-raised swine had sufficient trichinae to constitute a public hazard, whereas one animal in 72 constituted a potential hazard to the consumer of garbage-fed pork. Extrapolation to each group of our total swine slaughter would indicate that only one hog in 5,000 would be expected to contain sufficient trichina to constitute a public health problem. Garbage-fed swine, although they constitute less than 2% of our total pork supply, comprise more than 95% of the significantly affected trichinous hogs.

Probably of importance to the potential infection of man, is the fact that there are 2/3 as many garbage-fed swine today as there were nine years ago. The primary problem of trichinosis in swine undoubtedly has been the feed-back of infectious trichinous pork to swine with wildlife reservoirs always remaining a potential source. And, federal and local programs requiring the cooking of garbage have done much to lessen the incidence of trichinosis in garbage-fed swine. The Animal Disease Eradication Division has contributed much to the effectiveness of these programs. The effect, however, is that the apparent elimination of all viable trichina in the feed of swine has not accomplished the anticipated reduction in incidence of porcine infection. Further critical study of the problem is obviously essential.

The dramatic reduction in the incidence of trichinosis in farm-raised swine is tremendously encouraging. With further changes in animal husbandry practices, increased locker plant slaughter of farm consumed pork, and diminution of trapping by farm boys with resultant feeding of fur animal carcasses to swine, we can expect a continued decrease in the incidence of trichinosis in farm-raised swine.

Dr. M. R. Clarkson, Associate Administrator, Agricultural Research Service, early recognized the significance of the spectacular reduction in the incidence of trichinosis in swine and he appointed a committee within the Department of Agriculture to investigate and, if possible, to develop progressive measures to remove the stigma of danger from the consumption of pork. The activity of the committee promises a substantial contribution toward further reduction of the problem.

Of great importance in dealing with the trichina problem was the development, in the late 1950's, of systemic parasiticides. One of the most promising of these compounds is thiabendazole which has been reported to be quite effective for the treatment of experimentally-induced trichinosis in laboratory animals and swine.

I have been impatient for reports of the treatment of trichinosis in man with this drug. It is gratifying, therefore, that only last week (February 15, 1964) the Journal of the American Medical Association reported the successful treatment with this drug of a single case of human trichinosis. (Drs. Stone, Stone and Mullins, Galveston, Texas)

In summary, the following conclusions can be drawn:

1. Trichinosis in man in the United States has primarily originated from trichinous pork.
2. The incidence of trichinosis in farm-raised swine has been reduced by more than 95% since 1906.
3. The incidence of trichinosis in man has been reduced by 80% since the inauguration of the Federal meat inspection program in 1906.
4. The incidence of trichinosis in garbage-fed swine has been reduced by more than 75% since 1906, and the number and proportion of garbage-fed hogs has been greatly reduced.
5. These steps in progress together with the development of an effective chemotherapeutic agent for trichinosis in man, expectancy of the virtual elimination of trichina from farm-raised butcher hogs gives promise that the American consumer can unhesitatingly accept pork in the near future.

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